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PATENT- OCH REGISTRERINGSVERKET

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PATENT- OCH REGISTRERINGSVERKET

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DETECTION METHOD AND DEVICE

Description

Characteristic for the ever-growing anti-shoplifting industry of today is that the main profit is made from the sales of tags.

The reason for this is that the tags to which the detection systems will respond consist either of special magnetic materials (magneto-elastic, Barkhausen jump, magnetic saturation second harmonics, etc tag) or electrical circuits (LC resonant circuit tag) or components (the HF diode tag). All of these tags require dedicated manufacturing processes and are therefore relatively expensive. In general these processes and materials are proprietary and belonging to the anti-theft system producers. This renders each producer his own monopoly and control of tag sales and price.

The retail companies are today trapped between the necessity to use anti-theft systems to reduce shoplifting losses and the monopoly of the tag providers.

Invention

The new detection principle proposed here will change the scenario of the anti-theft market completely. Tags will no longer be proprietary elements using complicated materials or processes. They can be purchased by retailers or other tag users anywhere on the open market and to their choice and liking.

The price of the new tag will be 15.000 tags/SEK compared - in order of magnitude - to currently 4 tags/SEK.

The reason for this is that basically any electrically conductive material c an be used as tag with the new detection principle. A piece of copper or aluminium wire will make an excellent tag. From some aspects non-

magnetic materials could be preferred but also simple iron or steel wires can be used. Metallized plastic fibers are another example of a perfect tag and many other possibilities are open.

The unique feature of the tag lies in the combination of geometrical parameters and electrical resistivity (and magnetic permeability of the electrical conductor specified as the tag. This specification is set by the user into the detection system and this specification is all the user need to go out and buy the conductor material on the open market. Suppliers will be regular producers of copper wires, aluminium wires, iron wires, metallized fibers, etc.

The new detection principle is based on a special feature in the well-known skin-depth phenomena related to high-frequency electrical signals in electrical conductors. Skin depth describes the fact that the high-frequency conduction takes place in a skin layer of the conductor. The penetration depth of the skin is related to the AC signal frequency as well as the electrical resistitivy and magnetic permeability of the conductor itself.

The effective resistance of the conductor is therefore related to the skin layer cross-section (in product with the resistivity of the conductor material) which then will vary with the AC signal frequency. This relation is basically an inverse square root relation UNTIL the frequency when the skin depth reaches and equals the conductor radius (or minimum cross-section dimension for a rectangular conductor). At this point the AC resistance of the conductor will stop to decrease as the AC frequency decreases further. This point is therefore a discontinuity point in the AC resistance to AC frequency relationship (see fig 1).

The new tag can now be created simply by selecting a standard copper wire of a certain diameter and with known resistivity. This selects the frequency of the AC

resistance discontinuity point that is the special feature and detection criteria of the new tag.

Consider further a standard anti-theft electromagnetic coupling pedestal system seen in many shops and the new tag with the specified copper wire wound into a single turn loop. By applying a FM modulated excitation signal, with a frequency deviation sweeping past the tag discontinuity frequency value selected, and AM modulated tag signal will be received in the pedestal pick-up coils. This AM modulation results from the change in resistance of the copper wire loop as its skin depth changes with the excitation frequency. Starting at the maximum AC frequency the AM signal will increase in amplitude as the frequency decreases and the skin depth increases. However, at the frequency for which the skin depth reaches the copper wire radius the loop resistance ceases to decrease abruptly and creates a plateau (or flat region) in the received AM signal. Such a signal clipping at the frequency of the tag indicates the presence of the new tag in the anti-theft detection zone and is the criteria to trigger an alarm.

The clipping region represents the AC frequency interval during which the skin depth exceeds the conductor radius.

Different electronic or digital signal processing techniques can be utilised to precisely determine the AC frequency at the amplitude modulation (voltage drop) discontinuity related to the frequency modulation applied AC signal. One such technique is an amplitude demodulation of the AC voltage drop signal followed by subtraction of the FM reference signal and derivations to detect the discontinuity point.

One particular advantage of the new detection method is that the conductor radius detection criteria represents a discontinuity in the measuring signal - which easily can be distinguished from continuously varying features in the

measuring signal resulting from e.g. frequency related changes in inductance, reflections, capacitive couplings etc.

For the radio-link HF/microwave anti-theft systems a straight wire (dipole antenna tag) can be used instead of the loop used for the lower frequency systems. The antenna impedance of the wire will show a discontinuity in the same manner as in the case of the loop.

As an alternative to solid conductors also tubular conductors can be used as tags. Here it will be the thickness of the tube wall that will define the discontinuity point. One realisation of such a tubular conductor, particularly suitable for e.g. the fashion industry, would be a metallized synthetic fiber. One advantage of the tubular conductor over a solid equivalent is that the total volume of conductive material will be greater for the same skin-depth saturation point that will give larger tag signal levels.

To reduce the risk of false alarms due to tag similar conductors being present in the detection zone a coding of the new tag can easily and at now significant increase in tag price be realised. Such coding is achieved by letting the wire for the loop or antenna be made up of several wire pieces of different diameter and/or resistivities. Alternatively several loops or antenna elements can be grouped together to make up a coded tag (see fig 2). The accuracy of the radius to frequency relation should make a barcode equivalent wire-coded tag possible and realistic.

The new tag system therefore offers not only competition to existing anti-theft systems but also to the more advanced identity tag systems.

Yet another possibility to reduce the false alarm risk and to add a further coding parameter is to use non-circular cross-sections, e.g. rectangular cross-sections.

The minimum dimension can then measured by the discontinuity point. Taking the rectangular cross-section as an example the thickness would then be measured through the discontinuity point, remains then however the width. To measure that a secondary effect of the skin-depth can be used (see fig 3). For a certain change in skin-depth, delta-d, which relates to a certain delta-freq. the corresponding change in effective resistance, delta-R, will depend on the width. Or more general on the cross-section profile.

For materials where the permeability and/or the resistivity can be controlled by external influence special procedures need to be applied to know the values of these parameters during the process of skin-depth tag readings. One advantage, however, offered here is that several tags could be separated and thus read simultaneously by intelligent use of the external control influences, e.g. magnetic or electrical bias fields.

CLAIMS

1. Method for definition of identity c h a r a c t e r i z e d by the AC frequency for which the high frequency electrical conduction cross-section area (related to the so-called HF skin depth penetration) equals the geometrical cross-section - herewith defined as the skin depth saturation point - of a conductor with for its identity specific geometry and electrical resistivity and magnetic permeability characteristics.

2. Method to detect the AC frequency of claim 1, c h a r a c t e r i z e d by detection of a discontinuity in the AC impedance-to-AC frequency relation at the point of skin depth saturation.

3. Method to detect the discontinuity point of claim 2 c h a r a c t e r i z e d by detection of a phase shift between the tag excitation and detection signals.

4. Method to create numerical number identities using the method of claim 1, c h a r a c t e r i z e d by assembling a specific cluster of conductor elements.

5. Realisation of the method of claim 1, c h a r a c t e r i z e d by assembling wire or ribbon, e.g. a copper or aluminium wire or ribbon.

6. Realisation of the method of claim 4, c h a r a c t e r i z e d by that the conductor elements of the cluster are not in galvanic contact with each other.

7. Realisation of the method of claim 4, c h a r a c t e r i z e d by that the conductor elements of the cluster are in galvanic contact with each other.

8. Realisation of the method of claim 1, c h a r a c t e r i z e d by that the conductor element is a magnetic wire or ribbon, e.g. a simple iron or steel wire or ribbon.

9. Realisation of the method of claim 2, c h a r a c t e r i z e d by that the signal link between the detection system and the tag is a magnetic/inductive coupling.

10. Realisation of the method of claim 2, c h a r a c t e r i z e d by that the signal link between the detection system and the tag is a radio wave propagation signal.

ABSTRACT

A new tag and tag detection method allowing the use of virtually any electrical conductor material as tag, e.g. copper or aluminium wires.

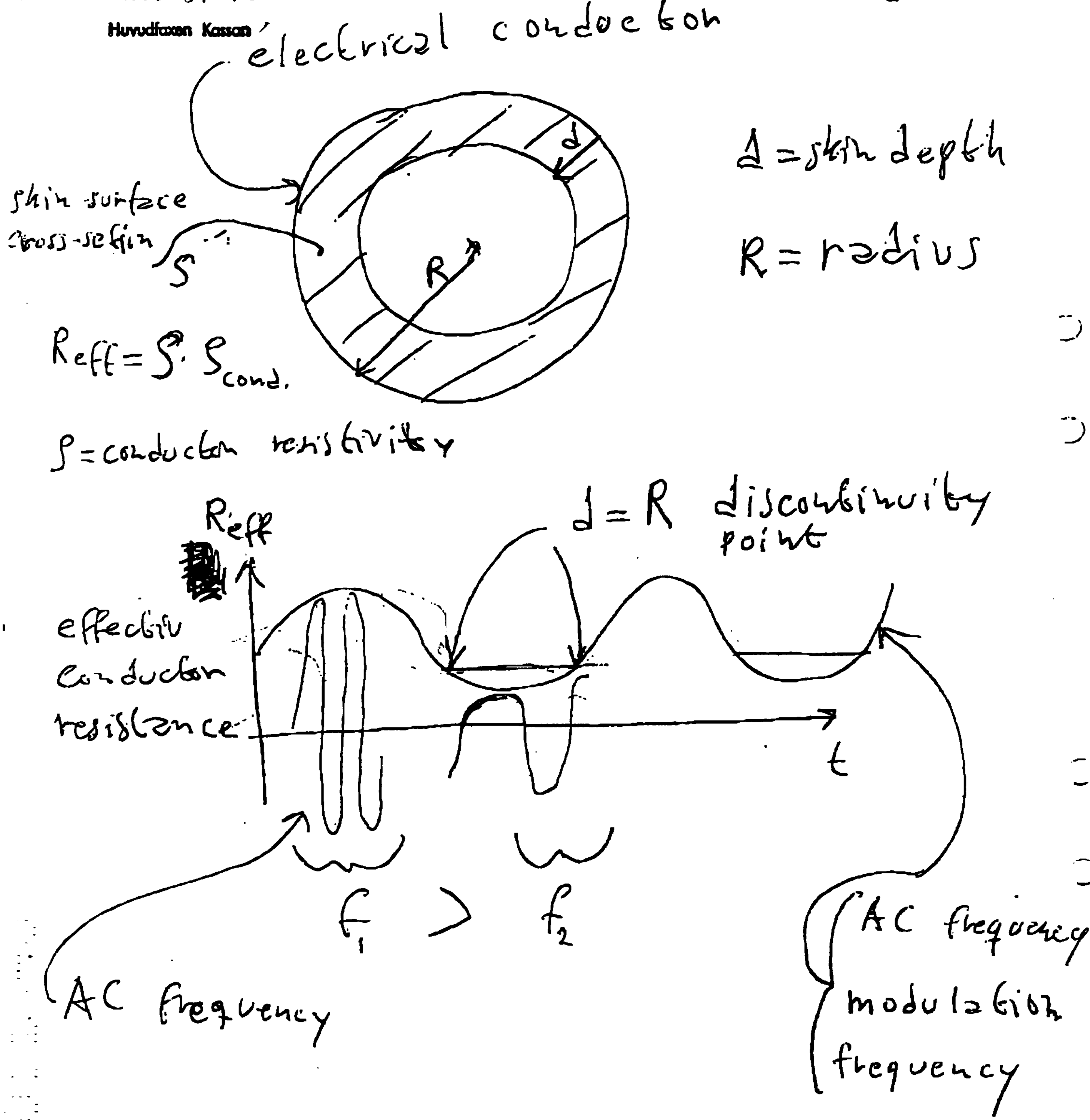
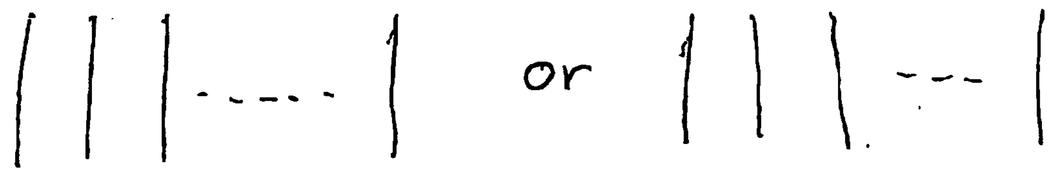


Fig 1

skin surface saturation point $\Rightarrow f_{sat} \Rightarrow d = R$

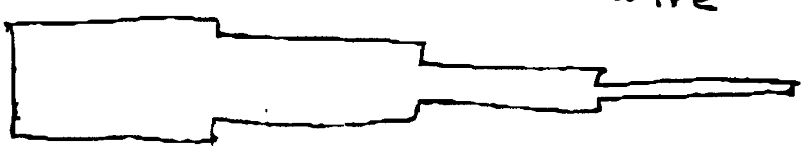
Ø = diameter ρ = resistivity



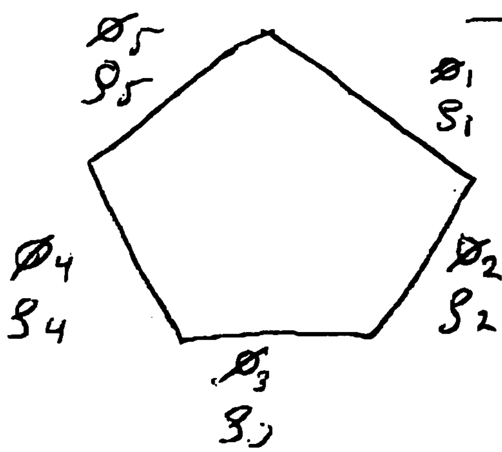
$\varnothing_1 \neq \varnothing_2 \neq \varnothing_3 \neq \varnothing_4$ $\rho_1 \neq \rho_2 \neq \rho_3 \neq \rho_4$

or combinations

or multiple diameter wire



Loops exampels



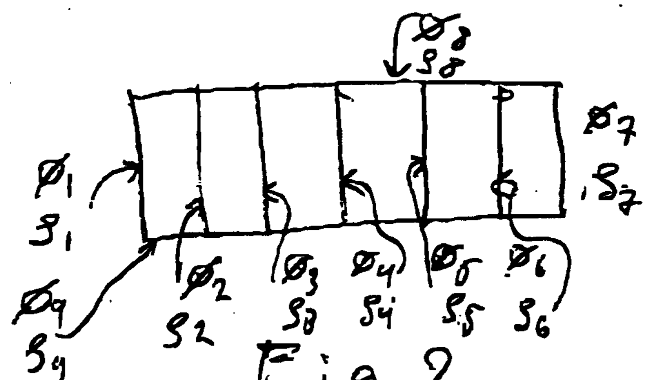
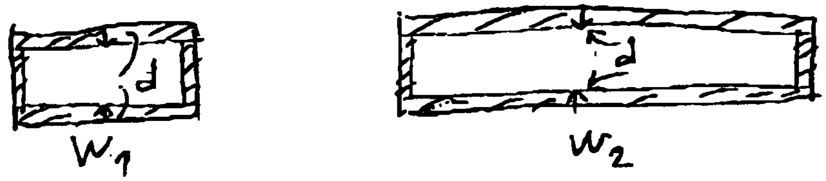
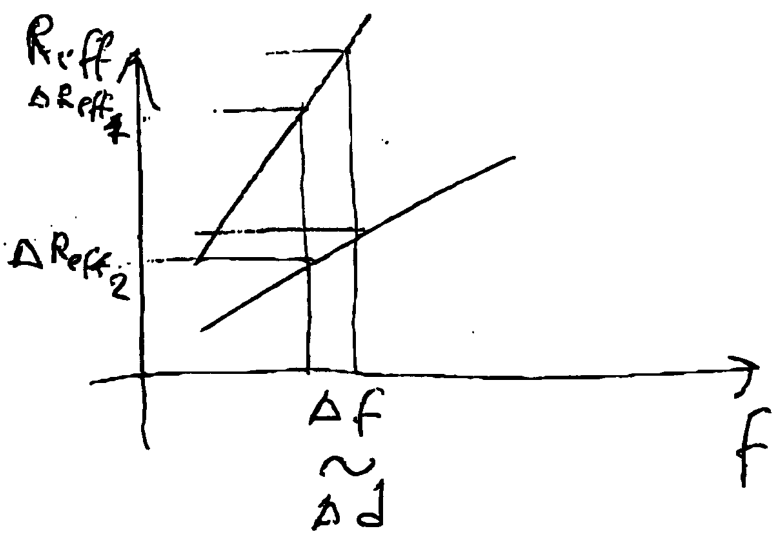


Fig 2

For magnetic wires Mr can also be used for coding

Secondary skin-depth effect





$$\frac{\Delta R_{eff_1}}{\Delta f} \sim W_1 \rho$$

$$\frac{\Delta R_{eff_2}}{\Delta f} \sim W_2 \rho$$

fig 2